PARENT MATERIAL WHICH PRODUCES SALINE OUTCROPS AS A FACTOR IN DIFFERENTIAL DISTRIBUTION OF PERENNIAL PLANTS IN THE NORTHERN MOJAVE DESERT

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Abstract.— An area of 0.46 km² divided into six zones in the northern Mojave Desert transitional with the Great Basin Desert has been studied. Diversity is high among the perennial plant species within the 0.46 km² area. Common species for the two deserts that are present in the area studied are *Atriplex confertifolia* (Torr. & Frem.) S. Wats., *Ceratoides lanata* (Pursh) J. T. Howell, *Grayia spinosa* (Hook.) Moq., *Ephedra nevadensis* S. Wats. Some other species present include *Lycium andersonii* A. Gray, *Lycium pallidum* Miers, *Ambrosia dumosa* (A. Gray) Payne., *Larrea tridentata* (Sesse & Moc. ex DC) Cov., *Acamptopappus shockleyi* A. Gray, and *Krameria parvifolia*, Benth. Some of the species are relatively salt tolerant and some are relatively salt sensitive. A total of 4282 individual plants were measured. There was considerable variation in distribution of the 10 dominant species present, apparently due to zonal variations of salinity dispersed within the study area. Correlation coefficients among pairs of the species for different zones illustrate interrelationships among the salt-tolerant and salt-sensitive species. Observations on an adjacent hillside with rock outcroppings indicate that the saline differences in this area are partly due to outcroppings of parent volcanic rock materials that yield Na salts upon weathering.

A vegetational map of a 0.46 km² area in Rock Valley of the northern Mojave Desert was presented elsewhere (El-Ghonemy et al. 1980, this volume). This is the Rock Valley Desert Biome validation site used in the International Biological Program (Turner 1973, 1975, 1976, Turner and McBrayer, 1974). The purpose of this report is to further explore the differences in plant species distribution on that site as influenced by zonal variations in salinity. The information involved also has relationships with the ecotonal lines studied elsewhere at the Nevada Test Site (Romney and Wallace 1980, this volume).

Materials and Methods

Data collected for the IBP validation site (Turner 1973, 1975, 1976, Turner and McBrayer 1974) and used in the development of a vegetational map and other findings (El-Ghonemy et al. 1980a and 1980b, this volume) were also used in this report. Sampling and data calculation procedures were described in those reports.

An additional 4 × 100m belt transect was established on a hillside further upslope from the main study plot. It was selected because of rock outcroppings that gave vegetational patterns somewhat similar to the differences observed within the large study plot. All plants were identified, counted, and measured by dimension analysis (Wallace and Romney 1972), and leaf tissue samples were taken for chemical analysis. Soil samples were taken at 10 m intervals along the transect. They were subjected to determination of EC and pH. For convenience of presenting results, the transect was divided into four plots each 25 m long. The rock outcrop was near the top of the transect.

Mineral element contents of plants were determined by emission spectrography; nitrogen was determined by Kjeldahl analysis; Cl was determined by titration.

Results and Discussion

The number of plants per hectare in various zones of the 0.46 km² plot are shown in Table 1. The zone numbers were designated in earlier IBP reports (Turner 1973, 1976, Turner and McBrayer 1974). Results serve to illustrate the differential distribution encoun-

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tered because of the soil differences. Zones 24 and 25 were the only ones having *Atriplex confertifolia* (Torr. & Frem.) S. Wats. This species is highly tolerant of salt (Wallace et al. 1973a). *Grayia spinosa* (Hook.) Moq. was present in Zones 20 and 21 in small numbers only, but was very prominent in Zones 23, 24, and 25. *Lycium andersonii* A. Gray was present in exactly the opposite manner, whereas, *Lycium pallidum* was distributed as was *G. spinosa*. *Lycium pallidum* Miers is much more tolerant of salt than is *L. andersonii* (Ashcroft and Wallace 1976, Wallace et al. 1973b, Beatley 1976).

Correlation coefficients were calculated for the species pairs for the data in Table 1 to further show relationships between the species according to differences in the soil involved (Table 2). *Atriplex confertifolia* was not included in these correlations because of its absence in four of the zones. Of salt-tolerant plants, *Lycium pallidum* and *G. spinosa* were positively correlated. Of salt-non-tolerant species, *L. tridentata*, *Krameria par-*

TABLE 1. Number of plants per hectare in the 0.46 km^2 study plot.

	Zone					
Species	20	21	22	23	24	25
Acamptopappus shockleyi A. Gray	46	—	28	45	28	101
Atriplex confertifolia (Torr. & Frem.) S. Wats	—	—		—	276	192
Ephedra nevadensis S. Wats	849	845	1177	1438	275	785
Ceratoides lanata (Pursh) J. T. Howell	155	951	122	2179	443	773
Ambrosia dumosa (A. Gray) Payne	1844	2474	2998	3877	2504	3402
Grayia spinosa (Hook.) Moq.	203	702	252	1830	2202	3388
Krameria parvifolia Benth.	1957	951	2103	1394	773	1166
Larrea tridentata (Sesse & Moc ex DC.) Cov.	1122	907	1205	1046	1004	1043
Lycium andersonii A. Gray	1136	452	981	713	83	314
Lycium pallidum Miers	88	706	224	697	815	1020
Total	7400	7988	9090	13219	8403	12184

TABLE 2. Correlation coefficients between number of plants/ha for the various species among zones in Rock Valley (± 0.700 needed for P = 0.05).

	Ephedra nevadensis	*Ceratoides lanata*	*Ambrosia dumosa*	*Grayia spinosa*	*Krameria parvifolia*	*Larrea tridentata*	*Lycium andersonii*	*Lycium pallidum*
Ephedra nevadensis S. Wats.	—	+0.534	+0.570	–0.287	+0.571	+0.373	+0.633	–0.303
Ceratoides lanata (Pursh) J.T. Howell	+0.534	—	+0.724	+0.352	–0.332	–0.415	–0.179	–0.470
Ambrosia dumosa (A. Gray) Payne	+0.570	+0.724	—	–0.555	–0.105	+0.033	–0.197	+0.517
Grayia spinosa (Hook.) Moq.	–0.287	+0.352	–0.555	—	–0.623	–0.338	–0.748	+0.888
Krameria parvifolia Benth	+0.571	–0.332	–0.105	–0.623	—	+0.890	+0.941	–0.858
Larrea tridentata (Sesse Moc. ex DC.) Cov.	+0.373	–0.415	+0.033	–0.338	+0.890	—	+0.700	–0.674
Lycium andersonii A. Gray	+0.633	–0.179	–0.197	–0.748	+0.941	+0.700	—	–0.900
Lycium pallidum Miers	–0.303	+0.470	+0.517	+0.888	–0.858	–0.674	–0.900	—

vifolia Benth., and *L. andersonii* were positively correlated. The individuals of the two groups were highly negatively correlated with one other.

Mineral analyses of leaves of plants from the various zones (Table 3) indicate little difference that can explain the results. The Cl concentration in leaves may be slightly higher from Zones 24 and 25.

The frequency of plant species in the four sections of the hillside transect (Table 4) showed characteristics similar to the large plot. Visual study of the transect area indicated that the salt-tolerant shrubs were more prevalent on sites containing outcrops of parent material. The average pH of the soil (0–15 cm) at the four intervals along the transect from bottom to top was 8.78, 8.90, 8.85, and 9.09. There were few differences except that the soil around the parent rock outcrop was slightly more alkaline. The EC (mmho/cm) values of the four soil samples beginning at the bottom were 2.43, 2.53, 2.07, and 2.75. None were really excessively

TABLE 3. Mineral element composition of leaf samples from the various zones. Samples taken in May 1973.

	N	Cl	P	K	Ca	Mg	Na	B
Zone	Percent of dry weight							ug/g
			Grayia spinosa (Hook.) Moq.					
20	3.48	0.90	0.24	3.01	1.82	—	1,635	52
20E	3.65	1.10	0.24	2.67	2.20	1.41	1,261	48
21	1.56	0.57	0.14	3.45	2.20	1.07	99	58
23	2.38	0.42	0.24	3.50	2.69	1.35	352	58
24	1.73	1.19	0.14	2.92	2.63	1.37	341	69
25	2.27	1.04	0.17	2.99	2.38	1.18	719	66
			Lycium andersonii A. Gray					
20	3.17	3.29	0.16	2.03	4.90	0.76	2,133	28
20E	3.33	4.18	0.17	1.65	5.06	0.88	2,739	35
21	3.21	4.93	0.15	2.09	5.71	0.88	3,000	30
22	3.15	4.57	0.19	1.83	4.90	0.87	2,453	33
23	3.14	4.14	0.22	2.14	5.96	0.97	3,268	37
24	2.86	4.95	0.14	2.34	6.73	0.89	3,276	35
25	3.24	6.46	0.18	1.54	5.21	0.68	2,228	31
			Lycium pallidum Miers					
20	4.19	1.98	0.29	2.15	3.74	1.08	12,600	56
21	4.08	3.47	0.20	1.68	3.96	1.18	10,600	20
22	2.85	2.61	0.18	1.49	3.35	1.15	2,100	34
23	3.26	2.59	0.16	2.11	3.84	1.26	2,700	40
24	3.18	3.83	0.17	1.28	4.81	1.34	2,200	47
25	3.26	4.02	0.15	3.04	5.54	1.22	3,000	20
			Larrea tridentata (Sesse & Moc. ex DC.) Cov.					
20	2.18	0.30	0.18	1.53	1.20	0.13	279	56
20E	2.18	0.24	0.21	1.90	0.90	0.21	328	48
21	2.37	0.16	0.26	2.06	1.34	0.18	343	72
22	1.97	0.12	0.27	1.72	1.67	0.26	377	56
23	1.95	0.17	0.34	1.68	1.45	0.23	811	67
24	2.12	0.30	0.24	2.40	1.08	0.18	473	74
25	2.04	0.33	0.21	1.74	1.31	0.20	867	77
			Atriplex confertifolia (Torr. & Frem.) S. Wats					
21	3.73	4.58	0.33	2.65	1.79	0.61	3.04	35
24	3.98	5.29	0.28	2.07	2.52	0.56	2.58	36
			Coleogyne ramosissima Torr.					
20	1.79	0.07	0.22	1.47	3.83	0.49	180	25
20E	2.06	0.01						
21	2.34	0.02	0.25	2.03	1.53	0.27	210	33
25	2.10	0.01	0.27	1.17	2.92	0.41	76	21

Table 3 continued.

Zone	N	Cl	P	K	Ca	Mg	Na	B
	Percent of dry weight						ug/g	
			Ceratoides lanata (Pursh) J.T. Howell					
21	3.55	0.16	0.29	2.66	0.93	0.34	194	20
23	3.73	0.37	0.32	2.45	1.55	0.54	103	35
24	3.40	0.24	0.29	2.61	1.53	0.39	90	27
25	3.07	0.32	0.29	2.58	1.19	0.33	74	26
			Ephedra nevadensis S. Wats.					
20	3.90	0.39	0.40	3.31	0.75	0.22	66	32
20E	4.05	0.34	0.90	5.43	2.39	0.66	228	57
21	4.00	0.40	0.41	3.05	0.73	0.19	68	33
24	3.52	0.35	0.36	3.20	0.57	0.18	135	26
25	4.24	0.51	0.37	3.55	0.70	0.18	96	27
			Ambrosia dumosa (A. Gray) Payne					
20	4.56	0.88	0.31	2.70	3.05	0.43	241	43
20E	4.18	0.72	0.37	2.94	1.47	0.42	237	88
22	4.57	1.03	0.39	2.83	1.93	0.52	483	59
24	4.28	1.23	0.32	2.70	3.11	0.48	261	89
25	4.25	1.33	0.32	3.94	2.75	0.46	563	82

saline within the first 15 cm of the soil profile. Nevertheless, the outcrops of exposed rock were high in sodium salts. The salt resulting from the weathering processes in the rock probably leaches away rapidly because of the slope.

Table 5 shows some other vegetational characteristics of this hillside transect. More detailed studies of these sites should elucidate some of the subtle ways that soil properties can determine the nature of vegetation in this desert.

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TABLE 4. Frequency of plant species in the four sections of the hillside transect (top is the rock outcrop with saline characteristics).

Species	Base ¼	¼	¼	Top ¼
	Transect on saline outcrop — Percent frequency			
Atriplex confertifolia (Torr. & Frem.) S. Wats	0.0	0.0	1.7	16.3
Psorothamnus fremontii (Torr.) Barneby	0.0	0.0	8.5	4.1
Ceratoides lanata (Pursh) J.T. Howell	9.7	9.7	20.3	6.1
Grayia spinosa (Hook.) Moq.	0.0	0.0	5.1	0.0
Lycium pallidum Miers	29.0	19.4	3.4	20.4
Larrea tridentata (Sesse Moc. ex DC.) Cov.	12.9	6.5	1.7	0.0
Lycium andersonii A. Gray	9.7	9.7	11.9	6.1
Ambrosia dumosa (A. Gray) Payne	3.2	9.7	13.6	18.4
Krameria parvifolia Benth	29.0	25.8	5.1	8.2
Machaeranthera tortifolia (A. Gray) Cronq. & Keck	0.0	6.5	3.4	12.2
Ephedra nevadensis S. Wats.	3.2	9.7	15.3	4.1
Lepidium fremontii S. Wats.	0.0	0.0	6.8	0.0
Sphaeralcea ambigua A. Gray	3.2	0.0	3.4	0.0
Oryzopsis hymenoides (Roem. & Schult.) Ricker	0.0	3.2	0.0	0.0
Encelia virginensis A. Nels.	0.0	0.0	0.0	4.1

TABLE 5. Vegetation characteristics of the hillside transect (divided into one-quarter segments for comparisons).

Species	Cover percent	Plant Rel.Dom. percent	Plant area m^2/ha	Plant volume m^3/ha	Plant biomass kg/ha
	Basal ¼ segment				
Ephedra nevadensis		1.4	22.1	9.3	13.4
Ceratoides lanata		1.7	26.7	15.6	47.1
Ambrosia dumosa		8.4	130.6	74.5	165.7
Krameria parvifolia		16.2	253.1	58.8	127.2
Larrea tridentata		19.1	297.6	192.5	304.6
Lycium andersonii		17.7	176.5	168.5	309.1
Lycium pallidum		35.2	548.7	336.1	274.4
Sphaeralcea ambigua		0.1	3.1	0.9	0.4
	15.58		Total	856.2	1242.0
	Lower ¼ segment				
Ephedra nevadensis		1.0	13.4	4.3	6.3
Ceratoides lanata		2.4	30.8	12.5	37.7
Ambrosia dumosa		4.6	60.2	19.4	43.2
Krameria parvifolia		21.1	275.8	62.7	135.5
Larrea tridentata		18.4	241.7	228.8	250.3
Lycium andersonii		22.1	289.8	203.1	342.1
Lycium pallidum		29.1	380.6	229.9	176.2
Oryzopsis hymenoides		0.1	0.8	0.1	0.9
Machaeranthera tortifolia		1.3	16.7	3.3	5.3
	13.10		Total	764.1	997.5
	Upper ¼ segment				
Atriplex confertifolia		1.7	23.7	10.7	54.8
Psorothamnus fremontii		14.6	199.8	76.7	189.5
Ephedra nevadensis		20.9	188.7	134.3	195.1
Ambrosia dumosa		11.1	152.3	58.8	176.9
Ceratoides lanata		11.6	158.4	51.1	113.7
Grayia spinosa		6.8	93.6	45.4	90.5
Krameria parvifolia		5.3	72.0	13.9	30.1
Larrea tridentata		0.9	12.6	3.8	22.7
Lycium andersonii		20.6	281.6	158.2	361.0
Lycium pallidum		4.8	65.3	31.1	40.7
Sphaeralcea ambigua		0.2	2.6	0.2	0.1
Lepidium fremontii		0.5	7.1	1.1	3.4
Machaeranthera tortifolia		1.0	13.3		
	13.69		Total	589.2	1284.9
	Top ¼ segment (rock outcrops)				
Atriplex confertifolia		17.5	144.4	59.6	305.8
Psorothamnus fremontii		3.1	25.5	7.1	17.6
Ephedra nevadensis		0.8	6.3	1.1	1.6
Ceratoides lanata		0.8	6.9	1.4	4.1
Ambrosia dumosa		23.9	196.5	56.2	125.2
Krameria parvifolia		16.9	139.0	27.8	60.1
Lycium andersonii		3.6	29.6	8.2	43.2
Lycium pallidum		27.8	229.2	85.0	135.5
Encelia virginensis		1.5	12.6	3.1	0.0
Machaeranthera tortifolia		4.1	33.6	8.2	13.2
	8.24		Total	257.7	706.4

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